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(54) VERTICAL RETORT FOR THERMAL PROCESSING OF LUMP SHALE

(71) We, NAUCHNO-ISSLEDOVATELSKY INSTITUT SLANTSEV, of Narvskoe shosse 12, Kokhtala-Yarve, and SLANTSEPERERABATY-VAJUSCHY KOMBINAT "KOKHTLA-YARVE" IMENI V.I. LENINA, of Kokhtla-Yarve, Narvskoe shosse 14, both Union of Soviet Socialist Republics, both corporations organised and existing under the laws of the Union of Soviet Socialist Republics, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described, in and by the following statement:—

The present invention relates to a vertical retort for thermal processing of lump shale.

Known in the art is a retort for processing oil shales in which they are subjected to low-temperature carbonization by a transverse-upward stream of a gaseous heat carrier (see e.g., V.A. Danilenko, Inventor's Certificate of the USSR No. 170463, Cl.10a,24,1965). In the top portion of this retort there is a low-temperature carbonization shaft, including two vertical shale-distillation chambers, a chamber for producing and distributing the heat carrier ("hot" chamber) arranged axially of the unit and between the shale distillation chambers, and two chambers for accumulating and discharging a steam-gas mixture ("cold" chambers). Thus, the low-temperature carbonization shaft is subdivided all along its height by four vertical lattice partition walls into five chambers. At the heat carrier inlet side of the low-temperature carbonization chambers (the "hot" side) the partition walls are made of a refractory material, and at its outlet side (the "cold" side) they are made of metal.

Mounted above the chambers are inclined bar screens with slots spreading out towards the "hot" side, ensuring the supply of a coarse fraction to the "hot" side of the chamber, the supply of a fine fraction being to its "cold" side.

The bottom portion of the retort accommodates a shaft for gasifying semicoke and for cooling waste residue. Here the process is also carried out in transverse-upward flow of gasifying agent.

The shale is charged by a special device into the top portion of the distillation chamber, where it is subjected to low-temperature carbonization by the action of the heat carrier having a temperature of 600—900°C. The heat required for that process is obtained both by burning some circulating gas in the hot chamber and by gasifying the semicoke in the bottom portion of the retort. The steam-gas mixture proceeds from the shale-distillation to "cold" chambers, whence it is discharged at a temperature varying from 150°C to 200°C into a condensing system through gas offtakes running in the top portion of the "cold" chambers. The waste residue is discharged by special devices from the bottom portion of the retort to be transported to dumps.

A significant disadvantage of this retort is

the accumulation of the fuel fractions on the "cold" side of the low-temperature carbonization chambers. This promotes high-rate bituminization of mineral, resulting in small pieces sticking together, in the clogging of the metallic partition wall, and adversely affecting the heating of a fuel bed; it causes a much greater carry-over of shale dust together with the steam-gas mixture, with small fuel particles slipping through the metallic lattice partition wall from the low-temperature carbonization chambers into those for accumulating and discharging the steam-gas mixture. Insofar as the bottom portion of the latter chambers has no openings for discharging the fine fuel fractions, it leads to their rapid overloading, and, naturally decreases the degree of utilization of fuel organic matters. As shown by practice, after 2 to 3 weeks the chambers of the above design are completely filled up with the material composed of the fallen fine fractions of both the shale and semicoke. As a result, the retort must be shut down for cleaning, this being a very labour-consuming and difficult operation. Moreover, a rather great carry-over of shale dust entrained by the steam-gas mixture causes serious deterioration of the quality of the tar, increasing its ash content.

Thus, the presence in the retort of the bar screens arranged in the top portion of the low-temperature carbonization chambers, and of the "cold" chambers adapted for accumulating and discharging of the steam-gas mixture but having no openings in their bottom portions for discharging the fine fuel fractions that have been accumulated therein, renders the retort ineffective for industrial operation.

As to the processing in this retort, with its narrow fuel bed, of shales low in organic matter (kerogen) which are most widely distributed over the globe, it is not possible at all. In view of the low hydraulic resistance and rather low filtering capacity of such shale, a great amount of shale dust and ash are carried away from the retort together with the steam-gas mixture, as shown by practical experience, with the dust and ash clogging the metallic lattice partition wall, the "cold" chamber, gas off-take and gas ducts, which get completely blocked up.

Moreover, due to the low thermal conductivity of fuel with a low organic-matter content, the narrow fuel bed allows heavy losses of heat with the steam-gas mixture, which does not make it possible to attain high utilization of the shale organic material in the low-temperature carbonization shaft and accounts for low yield and low thermal efficiency of the process.

Owing to the above-mentioned disadvantages the retort has not been used on an industial scale. For the sam reasons its construction concepts cannot be utilized for developing plants of a high unit capacity (e.g. 3000—4000 t of shale per 24 h), and those for processing oil shales with a low organic-matt r content, in particular.

Also known is another retort for processing oil shale, that has been successfully used on an industrial scale and wherein low-temperature carobonization is effected in an upward flow of gaseous heat carrier (see, e.g. M.M. Barschevsky, E.S. Bezmozgin, L.S. Zaglodin, A.S. Sinelnikov. Inventor's Certificate of the USSR No. 109152, Cl. 10a, 21, 1957). An upper portion of this retort accommodates a low-temperature carbonization shaft, including a chamber with an opening and a covering adapted for distributing a heat carrier, the chamber being arranged inside the bed axially of the plant. The chamber rests on a roof that separates the low-temperature shaft from that disposed in the bottom portion of the retort, adapted for gasifying semi-coke and for cooling solid residue and wherein the process is also carried out in an upward flow of a gasifving agent.

The shales are charged by a special device into the top portion of the low-temperature carbonization shaft where they are subjected to semicoking by the action of a heat carrier having a temperature of from 600 to 900°C. The heat required for the process is obtained as a result of gasification of the semicoke in the bottom portion of the retort. Gasifying gases produced therein at a temperature of 800—1000°C flow into the distributing chamber wherein air and the return circulating gas are introduced. From the distributing chamber the heat carrier at a temperature of 600—900°C is passed into fuel bed, and a steam-gas mixture is discharged from the low-temperature carbonization shaft at a temperature of 150—200°C into a condensing system through a gas off-take located in the top portion of the shaft. Waste shale residue is discharged by a special device from from the bottom portion of the retort, to be dumped.

A considerable disadvantage of this retort is that it fails to provide a possibility of adjusting heat carrier distribution in the fuel bed and, more precisely, the distribution of heat carrier flows on both sides of the distributing chamber. If, for some reason (e.g., shale segregation, bituminization, or slagging), an additional resistance originates in the fuel bed on one side of the distributing chamber, practically the entire stream of the heat carrier will be diverted to the fuel bed disposed on the other side of the chamber.

Thus, certain portions of the fuel bed accommodated in the low-temperature carbonzation chamber may happen to be highly overheated, wher as the oth r on s

are underheated with r spect to the low-temperature carbonization point. This results in lower tar yield and decreased chemical efficiency of the process.

The retort of th above design fails also to provide a possibility of controlling the uniform heating of material on both sides of the distributing chamber, insofar as the flows of the steam-gas mixture intermix upon emerging from the fuel bed in the retort sections, the temperature in the gas off-take (which may be indicative of the uniform heating of material in particular sections of the low-temperature carbonization shaft) representing a mean temperatue of the said flows, which does not provide the requisite information on the fuel heating in the low-temperature cabonization shaft. In any case this temperature carbonization shaft. In any case this temperature is completely unfit for ascertaining operatively on what side of the distributing chamber the fuel bed is subjected to intense heating and where it is underheated.

When such irregular heating if finally discovered (after the normal production conditions have been completely disturbed, either with the shales being discharged from the retort without suffering low-temperature carbonization or with the material not descending in one section owing to the formation of slag in the low-temperature carbonization shaft), the elimination of the irregularity presents a serious engineering problem. Under these circumstances, as has been shown by vast industrial experience, most frequently the retort must be shut down for clearing. This is largely attributed to the fact that, while eliminating the irregularities, it is impossible to provide different rates of material descent on both sides of the distributing chamber in the low-temperature carbonization shaft by making use of a single discharging device arranged in the bottom of the retort.

Finally, this retort suffers from one more disadvantage, i.e. relatively great carry-over of shale dust entrained by the steam-gas mixture. Upon drying off in the top portion of the low-temperature carbonization shaft the shales get into the high-rate steam-gas mixture stream. Naturally, the fine disperse dust is blown off the shale lumps and, as there is no filter bed in front of it, the dust is carried away together with the steam-gas mixture into the condensing system, clogging the gas off-takes and contaminating the resulting commercial tar.

The disadvantages of this retort are aggravated when its constructional principles are utilized for developing plants of a great unit capacity (e.g. 3000—4000 t of shale per 24 h, compared with the present retorts of the above-outlined construction, used on an industrial scale but having a capacity of about 150 t of shale per 24 h).

What is desired is a retort whose design would ensure a high capacity in terms of shale, preferably 3000—4000 t per 24 h. It should provide the possibility of processing oil shales low in organic matters, that are widely distributed over the globe.

The present invention provides a vertical retort for thermal processing of lump shale, comprising a body which accommodates a low-temperature carbonization shaft, a gasifying shaft, and a cooling shaft arranged one above another, the low-temperature carbonization shaft having two vertical perforated partition walls extending along its entire height and subdividing it into a chamber adapted for supplying and distributing a heat carrier flanked by two low-temperature carbonization chambers provided with individual gas off-takes, the gasifying shaft communicating with heat carrier supply chambers located at its periphery; respective charging means for separately supplying lump shale to the respective low-temperature carbonization chambers; and respective low-temperature carbonization chambers; and respective means for separately discharging solid residues from the cooling shaft at respective positions below the respective low-temperature carbonization chambers.

It is expedient for the said charging means to feed the shale into each low-temperature carbonization chamber at a position which is displaced with respect to the median axis of the respective carbonization chamber towards its "hot" side, i.e. towards the associated partition wall.

Owing to a high degree of filling of the volume of the low-temperature carbonization shaft with the shales (e.g. 60—70%) the design of the retort can provide for high capacities in terms of shale, e.g. 3000—4000 t per 24 h. The presence of separate low-temperature carbonization chambers with individual gas take-offs allows the process conditions in each chamber to be monitored individually and adjusted by the respective discharging means. This creates favourable conditions for ensuring a high yield of tar and a high thermal efficiency of the process.

The absence of bar screens in the top portion of the low-temperature carbonization chambers makes it possible to avoid concentration of fine shale fractions on the "cold" side of the said chambers. Moreover, the displacement of the feed from the charging devices towards the "hot" sides of the carbonization chambers enhances the filtering capacity of a bed in terms of shale dust and fines (with the latter being accumulated, owing to the above charging technique, at the "hot" side of the low-temperature carbonization chambers).

This provides, as has been shown by experimental investigations, a two-threefold decrease in the shale dust carry-over with the steam-gas mixture, with the gas off-takes being blocked up with deposits not so quickly as on the prior-art retorts. As a result, the run between repairs is extended, and tar contamination with solids from the said carry-over, and hence its ash content diminish.

Thus, the retort offers, as compared with the prior-art units, a higher capacity in terms of shale, together with higher tar yield and better terminal efficiency of the process; it also makes it possible to extend the run between repairs and to enhance the quality of the tar obtained (to decrease its ash content).

The invention will be described further, by way of example only, with reference to the accompanying drawings, whose sole Figure diagrammatically shows a vertical retort for thermal processing of lump shale, in vertical cross-section.

The illustrated retort comprises a body 1(e.g. of rectangular cross-section) accommodating a low-temperature carbonization shaft 2, a semicoke gasifying shaft 3, and a cooling shaft 4, these shafts being arranged one above another.

The low-temperature carbonization shaft 2 is provided with two vertical perforated partition walls 5 extending along its entire height and subdividing it into two low-temperature carbonization chambers 6 flanking a chamber 7, for supplying and distributing a heat carrier, formed between the partition walls 5. This embodiment of the low-temperature carbonization shaft 2 allows it to be filled with shale to 60—70% of its overall volume, this being a comparatively high capacity for shale.

The semicoke gasifying shaft 3 is partly defined by refractory walls 10 having orifices 9 through which the shaft 3 communicates with chambers 8 for supplying a heat carrier to the periphery of the gasifying shaft 3. The chambers 7 and 8 are provided with gas burners 11 and gas inlets 12.

The shales are fed into the retort from bins 13 by means of automatic charging devices 14 whose upper parts contain respectively proportioning slide gates 15 and whose lower parts cooperate with respective suspended cones 16 controlling communication between the charging devices 14 and the upper ends of the respective chambers 6. The charging devices 14 feed the fuel into each chamber 6 at a position which is displaced from the median axis of the chamber towards the "hot" side of the chamber (the side through which the heat carrier is fed into the fuel bed). A gaseous mixture is discharged from the chambers 6 through individual gas off-takes 17.

The shaft 4 for cooling solid shale residue accommodates devices 18 for supplying cooled gas an outlet bins 19 for discharging solid material, each bin being spaced above the cylindrical bottom of a liquid seal container 20. Each liquid seal container 20 is provided with a system of gears (not shown) adapted for pushing and discharging the solid residue from the retort.

The above described retort operates in the following manner. The lump shales are fed from the bins 13 by the charging devices 14 and directed towards the "hot" sides of the low-temperature carbonization chambers 6. With the above charging system the finer shale particles are accumulated on the "hot" sides of the chambers 6, increasing the density of the bed here, thereby inhibiting carry-over of shale dust with the gaseous mixture from the retort, precluding the fouling of the gas off-takes 17 and, hence, extending oven life between repairs and improves the quality of tar (diminishing its ash content). In cases where the shale being processed tends to undergo bituminization on heat to 400—450°C, the concentration of the fine shale on the "hot" sides of the low-temperature carbonization chambers 6 prevents serious after-effects of such bituminization during semicoking (only the fine shale accumulated in low-temperature zones being responsible for bituminization). Upon passing into the low-temperature carbonization chamber 6 the shales are heated by a stream of the gaseous heat carrier having a temperature of 500—900°C (the temperature being dependent on the quality of shales being processed) introduced from the distributing chamber 7 through the walls 5 and passing in a transversely upward direction through the descending shales. Some heat carrier is produced by combustion of gas in the bottom portion of the chamber 7, this portion being equipped with burners 11 and gas inlets 12 for this purpose. By varying the gas flow-rate it is possible to keep the temperature of the heat carrier at the prescribed level. The remaining heat carrier rises from the gasifying shaft 3.

The presence of a rather large fuel bed(in the direction of heat carrier flow) in the low-temperature carbonization chambers 6 creates an increased hydraulic resistance and enhances the filtering capacity of the bed, this providing favourable conditions for low-temperature carbonization of the shales low in organic matters which are widely spread over the globe. A higher hydraulic resistance of the fuel bed ensures more uniform distribution of the heat carrier inside the bed and, hence, improves heat transfer, this being conductive to higher tar yi lds and better thermal efficiency of the process.

At the same time it enhances the filtering capacity of the bed, which also contributes to a reduction in shale dust carry-over from the retort tog ther with the gaseous mixture.

The gaseous mixture is discharged at a maximum temperature of 150—200°C from the low-temperature carobonization shafts 6 through the gas off-takes 17. The use of separate chambers 6 passing individual gas off-takes 17 allows the shale semicoking in the chambers to be controlled separately (depending on the temperature of the gaseous mixture in the respective gas off-takes).

Semicoke passes from the low-temperature carbonization chambers 6 into the shaft 3 for gasifying or additional heating by introducing accordingly either a gasifying agent (a steam-air, gas-air, or smoke-air mixture and, possibly, flue gases) or a heat carrier (a mixture of flue gases and the fuel gas) from the side chambers 8 provided with the burners 11 and gas inlets 12 and with steam inlets, if required (not shown in the drawing).

Gas streams proceed from the shaft 3 both to the chamber 7 and directly into the fuel bed in the semicoking chambers 6, ensuring thereby uniform heating of the fuel. The most favourable operating conditions of the shaft 3 are selected experimentally.

The solid residue is passed from the shaft into the cooling shaft 4 where it is cooled to a temperature of 80—100°C by the gas fed through the devices 18. Next it proceeds further into the bins 19 and liquid deal container 20, whence it is discharged by the pushing gears into conveying devices to be dumped to ash heaps.

Owing to the individual charging device 14 that is provided for each low-temperature carbonization chamber 6, the fuel descent rate can be adjusted in each chamber 6 independently. In combination with individual gas off-takes 17 mounted in each chamber 6, it affords the possibility of monitoring and adjusting the regime while distilling the shales in the semicoking shaft 6, this creating favourable prerequisites for both high tar yield and improved thermal efficiency of the process.

WHAT WE CLAIM IS:—

1. A vertical retort for thermal processing of lump shale, comprising a body which accommodates a low-temperature carbonization shaft, a gasifying shaft, and a cooling shaft arranged one above another, the low-temperature carbonization shaft having two vertical perforated partition walls extending along its entire height and subdividing it into a chamber adapted for supplying and distributing a heat carrier flanked by two low-temperature carbonization chambers provided with individual gas off-takes, the gasifying shaft communicating with heat-carrier supply chambers located at its periphery; respective charging means for separately supplying lump shale to the respective low-temperature carbonization chambers; and respective means for separately discharging solid residues from the cooling shaft at respective positions below the respective low-temperature carbonization chambers.

2. A retort as claimed in claim 1, in which the charging means feed shale into each carbonization chamber at a position which is displaced with respect to the median axis of the respective carbonization chamber toward the associated partition wall.

3. A vertical retort for thermal processing of lump shale, substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

MARKS & CLERK

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1491645 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*